Research Paper | Engineering | E-ISSN No : 2454-9916 | Volume : 3 | Issue : 5 | May 2017

COMPARISON DYNAMIC ANALYSIS BETWEEN BLOCK AND FRAMED FOUNDATION FOR ROTARY MACHINE

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ABSTRACT

Remarkable advancement in field of science and technology. As the celerity of machinery has incremented, vibrations withal incremented. Machines transmit vibrations to the structure fortifying them. It is consequential to design and develop such structure which sustains the vibrations of machinery. In just beginning countries like India, vibration quandaries from industrial assets have been drawing attention of machine manufacturer and engineers since decades, world over to find ways and mean to have desired copacetic Performance of machines and to minimize failures. The vibration may engender quandary of resonance in structure and there by damage the structure. This necessitated a research in the area of dynamics of machine substructure. Frequency increased than its vibration is increasing so it's very harmful effect of foundation. More effective foundation development necessitated for higher capacity machine. This research aims to study the dynamic behaviour of a foundations structure for rotary machine subjected to forces due to operation of machine and performance of foundations.

KEYWORDS: Machine foundation, Rotary machine, Dynamic analysis, Vibration, Displacement, Modes, Frequency.

I. INTRODUCTION

When a building or a bridge is erected on the ground, its foundation and the soil below shall be subjected to static loads only. However, when machine is installed on the ground, its foundation and the soil below shall be subjected not only to static loads but also to the dynamic loads caused by the vibrating machine.The vibrations induced by the working of a machine in the ground and the surrounding buildings and structures, may cause serious harmful effects, besides causing annoyance to the persons working in the area around the machine. These harmful effects can be best controlled by proper design of the machine foundation. The design of the foundation required for installing a machine, therefore becomes important and needs special attention.

The basic philosophy underlying design of machine foundation is that: a) The dynamic forces of machines are transmitted to the soil through the foundation in such a way that all kinds of harmful effects are eliminated and the amplitude of vibration of the machine as well as that of the foundation are well within the specified limits and b) Foundation is structurally safe to withstand all static and dynamic forces generated by the machines. The main constituents of a typical machine foundation system are: Machine: rotary machines, reciprocating machines, impact machines; Foundation: block foundations, or frame foundations; and Support medium: soil continuum, or a soil-pile system, or a substructure that, in turn, is supported over the soil continuum or soil-pile system.

The dynamic response of block foundations can be analysed by three methods: a) Empirical and semi-empirical formulae b) Soil-as-spring approach c) Elastic –half –space approach. Barkan's method is recommended for the dynamic analysis of block-type machine foundations. The theoretical basis of this method is outlined below: Let it be assumed that the combined center of gravity of the machine and foundation lies in the same vertical translation and twisting modes are uncoupled, while the sliding and rocking motions in each of the two vertical planes (xz and yz planes) passing through the common center of gravity of machine and foundation are separately coupled. The motion of the foundation in the xz plane will be examined first. And framed foundation models are also restricted to one or two degree of freedom system and modelling in framed wise. Three manual methods are available for the dynamic analysis of framed foundation namely, the "resonance method", "amplitude method", and "combined method". The resonance method and amplitude method are complimentary; the combined method. In frame foundation following practices are generally employed i) Foundation is split in to as many numbers of portal frames as present ii) Transverse and Vertical vibrations are evaluated for these portal frames iii) Top deck being rigid, lateral vibrations coupled with torsional vibrations are evaluated using lateral stiffness properties of each portal frame. Longitudinal vibration is generally not attempted using manual method of analysis these cases are discussed one by one.

II. RELATED WORK

The dynamic analysis of framed and block substructures for rotating machine is done by following approach. Study of structural system of the machine substratum in industry and understanding the working of the rotary machine. Accumulation of obligatory machine data such as the dimension of the machine, its operation celerity, frequency of the motor, RPM of motor and blower, Mass of motor etc. Withal, the data regarding the substratum have been amassed. Preparation of drawing of foundation plan exhibiting layout of machine position on the substructures utilizing CAD software. Satisfactory design of a machine foundation needs information of soil profile, depth of different layers, physical properties of soil and ground water level. Dynamic shear modulus of a soil is generally determined from laboratory or field tests. The soil properties needed in analysis of foundation are: [1] Dynamic modulus, Young's modulus E and Shear modulus [2] Poisson's ratio μ [3] Dynamic elastic constants such as coefficient of elastic uniform compression Cu, coefficient of elastic uniform shear $C\tau$, coefficient of elastic non-uniform compression $C\varphi$ and coefficient of elastic non-uniform shear $C\psi$ [4] Damping ratio ξ

- Vibration performance criteria: The main purposes of the foundation system with respect to dynamic loads include limiting vibrations, internal loads, and stresses within the equipment. The foundation system also limits vibrations in the areas around the equipment where other vibration-sensitive equipment may be installed, Personnel may have to work on a regular basis, or damage to the surrounding structures may occur. This performance Criteria are usually established based on vibration amplitudes at key points on or around the equipment and foundation System. These amplitudes may be based on displacement, Velocity, or acceleration units. Displacement limitations are commonly based on peak-to-peak amplitudes measured in Mils (0.001 in.) Or microns. Velocity limitations are typically based on either peak velocities or root-mean-square (rms) velocities in units of inch per second or millimeter per Second. Displacement criteria are almost always frequency dependent with greater motions tolerated at slower speeds. Velocity criteria may depend on frequency but are often independent. Acceleration criteria may be constant with Frequency or dependent.

- As a first approach for modeling the problem we can assume that the soil is elastic. In this case seems natural to model the soil by linear springs. Such a model, masses supported on elastic springs, exhibits natural modes of vibration. It is well known that these systems when excited at certain frequencies vibrate with very large displacements .In fact, with infinite displacements according to the mathematical model (Resonance phenomena). This phenomenon is not observed in the practice because the soil extents are infinite and we are in presence of an open system, instead of a closed one. In open systems the kinetic energy of the particles in the vicinity of the foundation escapes in the form of travelling waves propagating in the soil.

- Than the creating model pre-processor is the Specifying the units, Discretisation of whole structure, Creating the model, Assigning properties, Assigning support conditions, Application of loads and last the post processor view output file and stay with models.

III. REQUIRED MACHINE DATA

Block machine foundation data:

Length (mm) = 6000, Width (mm) = 2400, height (mm) = 2500, Mass density of Concrete = 2500 kg/m³, mass density of soil = 1800 kg/m³, Cu = 46000 kN/m³, poisson's ratio = 0.25, damping constant = 0.1, Shear modulus G = 13500 kN/ m².

Framed machine foundation data:

Length (mm) = 9700, Width (mm) = 5800, height (mm) = 8800, Mass density of Concrete = 2500 kg/m³, mass density of soil = 1800 kg/m³, Cu = 46000 kN/m³, poisson's ratio = 0.25, damping constant =0.1, Shear modulus G=13500 kN/m².Here, Cr = 32671.3835 kN/m³,Cθ & Cϕ=130685.534 kN/m³, Cψ = 49007.0753 kN/m³ define this value by the Cu correlation between them.

IV. EXPERIMENT RESULT

Figures and tables shows the results of dynamic analysis of the framed and block foundation Before modelling the foundation, it is necessary to check the preliminary dimensions of block foundation, and mass ratio checks, eccentricity check and bearing capacity check by the guidelines given in Suresh Arya's book, IS 2974-III:1992. Then also amplitude defines by guidelines in K.G. Bhatia. And Here Clockwork 11.1 is the using of the Impedance Method also Dynamic Analysis using by the Empirical Method. Also necessary to check for framed foundation its dimensions and other criteria so it's consider a typical top deck plan with three frames distribution of machine loads on deck slab. For load nomenclature, refer a representative typical portal frame as shown in Figure. In order to evaluate loads associated with each frame, it requires: i) Identify machine loads at the deck and allocate the same to the nearest frame beam or longitudinal beam as the case may be using law of statics ii) Evaluate self weight of each member at the top deck and transfer the same on to the frame beams/longitudinal beams using law of static iii) Evaluate self weight of each column

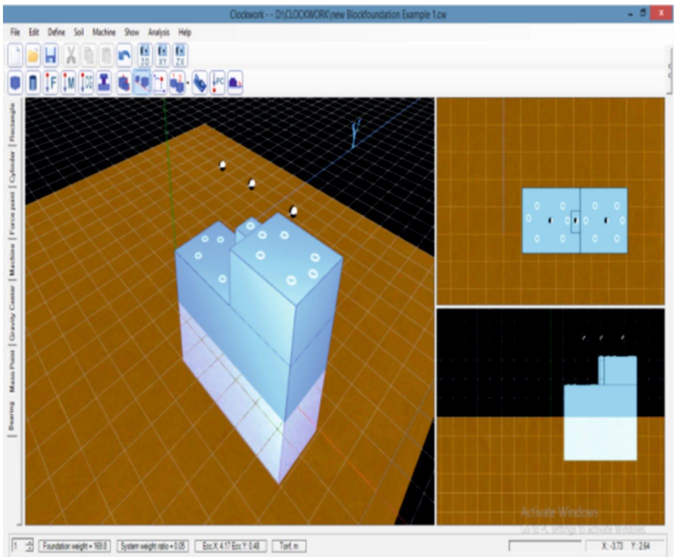

Fig. 1 - Screenshot of Applied soil data and bearing

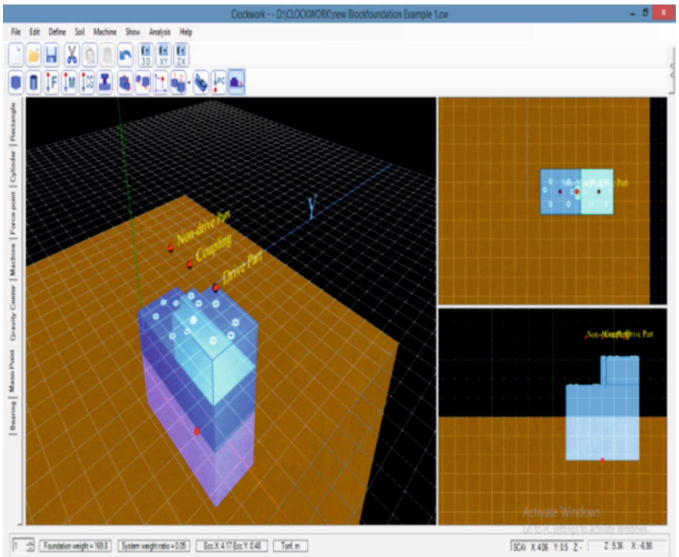

Fig. 2 – Name of part in machine foundation

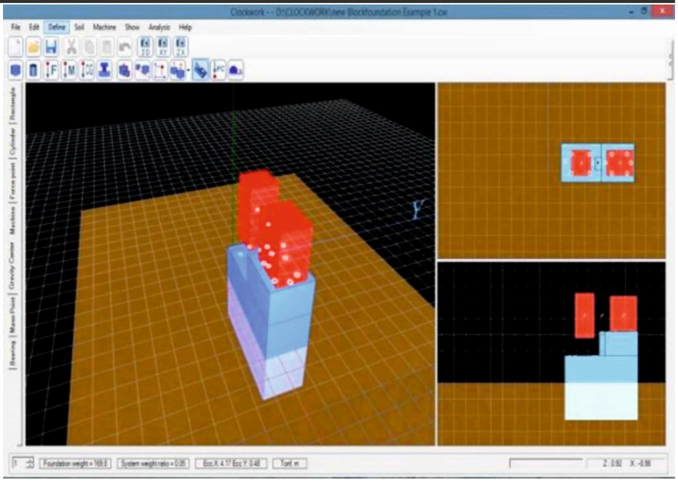

Fig. 3 – Drive and non-drive part position

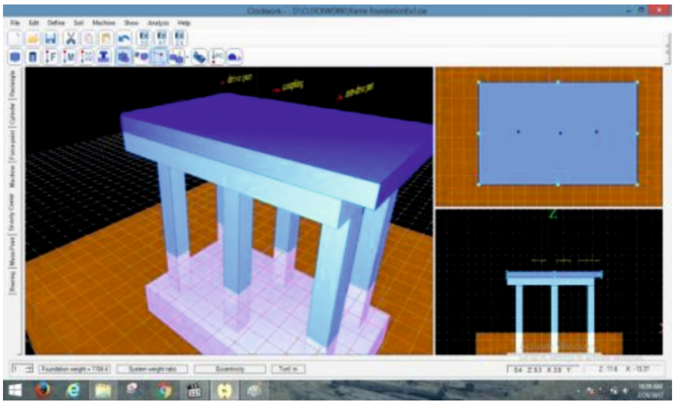

Fig. 4 – Frame foundation modeling

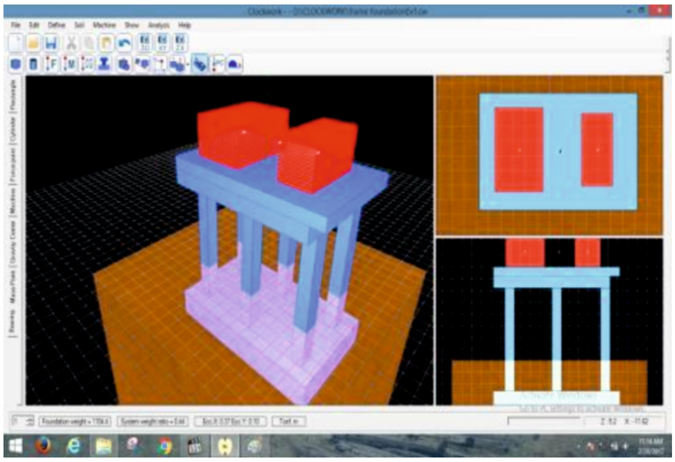

Fig. 5 – Machine position of frame foundation

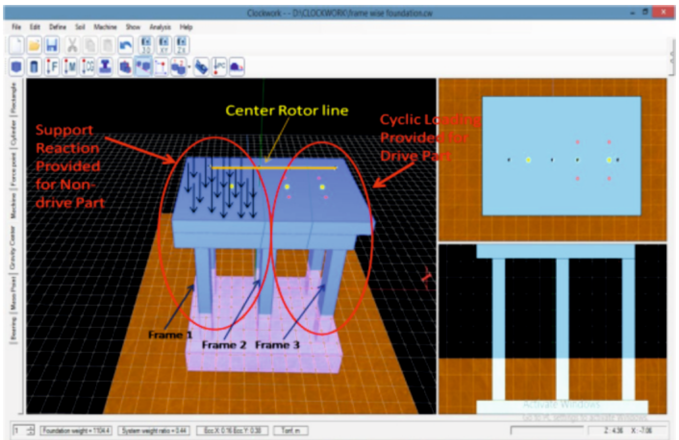

Fig. 6 – Frame foundation of frame wise loading

Comparison of Block Foundation Manual and Software Results:

Table No. 1: Results of foundations (a) Displacement (b) Rotational moment (c) Natural

(a) Displacement (m):

Displacement	Block foundation	Frame foundation
Along X in phase	2.024223E-06	4.386985E-06
Along X out phase	1.627996E-06	3.184945E-06
Along Y in phase	9.871705E-06	3.900504E-06
Along Y out phase	4.176608E-06	2.589914E-06
Along Z in phase	1.889539E-07	4.13887E-05
Along Z out phase	9.414261E-08	4.44808E-05

(b) Rotational Moment about X,Y and Z direction (kNm) :

Foundation	Rocking (kNm)	Yawing (kNm)	Pitching (kNm)
Block Foundation	2.259702E-06	1.472455E-06	4.368217E-08
Frame Foundation	3.046108E-06	2.961403E-06	3.524764E-08

(C) Natural Frequency (Hz):

Mode Number	For Block foundation	For Frame foundation
1	1.352	2.878
2	1.920	3.437
3	3.921	6.375
4	8.896	12.144
5	15.588	15.543
6	22.540	18.196

Allowable Displacement Based on ACI 351-3R-04 and IS: 2974 Part1 to 4 for high frequency machine permissible to the 40 micron (40E-06 m). And for most soil type foundations for machine to limiting amplitude of 200 microns or frequency below 20Hz. Here the z-direction values also known vibration.

V. CONCLUSION

As far as X-direction displacement is concern, Block Foundation shows good performance as compare to Frame Foundation for that type of soil property. From Result table it is clearly visible that Frame Foundation has maximum displacement in X-In phase and out phase than Block Foundation because Frame Foundation shows more flexible behavior structurally. Hence, displacement is more in case of block foundation. As far as Y-direction displacement is concern, Frame Foundation is better in performance as compare to Block Foundation. In that the Frame foundation more efficient for Block foundation in Y- in phase but in out phase are the nearly same for the frame foundation. In Z- direction vibration are the more in frame foundation compare to the block foundation in that type of soil condition. So, Block foundation are the more suitable for the Frame foundation that type of model condition.

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